(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
10 October 2002 (10.10.2002)

PCT

(10) International Publication Number
WO 02/079604 A2

(51) International Patent Classification[7]: E21B 23/04, 29/00, 10/32

(21) International Application Number: PCT/GB02/01505

(22) International Filing Date: 28 March 2002 (28.03.2002)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0108144.7 31 March 2001 (31.03.2001) GB

(71) Applicant *(for all designated States except US)*: **ROTECH HOLDINGS LIMITED** [GB/GB]; Whitemyres Avenue, Mastrick Industrial Estate, Aberdeen AB16 6HQ (GB).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **VAN DRENTHAM-SUSMAN, Hector, Filippus, Alexander** [GB/GB]; Pinjarra, Pitcaple, Inverurie, Aberdeenshire AB51 5EE (GB). **STEWART, Kenneth, Roderick** [GB/GB]; Greens of Crynoch, Blairs, Aberdeen AB12 5YX (GB). **WHITE, Robert, Graham** [GB/GB]; The School House, Nether Kinmundy, By Longside, Peterhead, Aberdeenshire AB41 4YN (GB).

(74) Agents: **MCCALLUM, William, Potter** et al.; Cruikshank & Fairweather, 19 Royal Exchange Square, Glasgow G1 3AE (GB).

(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *without international search report and to be republished upon receipt of that report*

WO 02/079604 A2

(54) Title: EXPANDABLE DOWNHOLE TOOL

(57) Abstract: The present invention provides a down-hole tool (7) with at least one radially outwardly deployable tool element (33) for use in a bottom hole assembly (1) provided with a pressurised down-hole motor drive fluid supply (50). The tool (7) comprises a body (9) having at least one tool element (33) having a mounting, proximal, end portion (32) pivotally mounted (31) on said body, and a working, distal, end portion (34) displaceable between a stowed, radially inward, position and a deployed, radially outward, position. The proximal end portion (32) is provided with an engagement portion (29, 30) formed and arranged for driven engagement with a drive member (23) axially displaceable by a piston and cylinder device (19, 20). In use of the tool (7), axial displacement of the drive member (23) causes said proximal end portion (32) to rotate and displace said tool element working end portion (34) between said stowed and deployed positions thereof.

EXPANDABLE DOWNHOLE TOOL

The present invention relates to down-hole tools, and more particularly to down-hole tools which are required to pass through pipe constrictions of substantially smaller diameter, than that part of the pipe in which the tool is required to be worked.

Conveniently such tools have tool elements which are provided with more or less complex linkage mechanisms for displacement of the tool element between a stored, radially inward, position and a deployed, radially outward, position, generally using a remotely controlled hydraulic fluid operated drive means. Such arrangements on the one hand involve significant manufacturing cost and complexity, and on the other hand are susceptible to malfunction due to linkages jamming or differential displacement of multiple cutting elements which can result in overloading of an individual cutting element etc.

It is an object of the present invention to avoid or minimise one or more of the above disadvantages.

The present invention provides a down-hole tool with at least one radially outwardly deployable tool element for use in a bottom hole assembly provided with a pressurised down-hole motor drive fluid supply, which tool comprises a body having at least one tool element having a mounting, proximal, end portion pivotally mounted on said body, and a working, distal, end portion displaceable between a stowed, radially inward, position and a deployed, radially outward, position, said proximal end portion being provided with an engagement portion formed and arranged for driven engagement with a drive member axially displaceable by a piston and cylinder device operable,

in use of the tool, by means of said pressurised drive fluid supply.

Various suitable forms of drive member and engagement portion combination may be used in accordance with the present invention. The drive member may simply make use of its axial displacement to displace the tool element. Alternatively the drive member could be provided with a guide device mounted for action between the drive member and an opposed body part so as to impart a greater or lesser degree of angular rotational displacement to the drive member when it is axially displaced by said piston and cylinder device. A suitable guide device could comprise a guide channel or slot and a guide pin received in said channel or slot for running therealong. The guide channel or slot could, for example, extend generally helically around a generally cylindrical part of the drive member, or could have generally 'J' shaped form or the like. It will of course be appreciated that such a guide channel or slot could be provided at any convenient part of the tool so as to provide the desired rotation of the drive member. Thus, for example, it could be provided on the piston, the piston being coupled to the drive member so as to transmit rotational drive thereto in addition to axial drive. Naturally also equivalents of such guide devices in which the male and female components (guide pin and guide channel or slot) are inverted, are also included within the scope of the present invention.

In one form of the invention the drive member may be provided with a cam portion and the engagement portion constitutes a cam follower. The cam follower would extend generally longitudinally in the case of a drive member having only an axial component of motion, or could extend generally annularly in the case of a drive member having a rotational component of motion.

In another form of the invention, the engagement portion comprises a pinion gear sector portion, and the drive member would be provided with a rack gear portion in the case of a drive member having only an axial component of motion, or with a worm gear portion in the case of a drive member having a rotational component of motion.

Conveniently the piston and cylinder device is provided with a resilient biasing means formed and arranged for urging said rack member towards a stowage position in which said at least one tool element is stowed, said piston and cylinder device being formed and arranged for displacement of said rack member against the biasing force of said resilient biasing means when an increased fluid pressure differential is applied to said piston and cylinder device.

Conveniently the rack or worm type drive member is provided on or as part of the piston rod of a reciprocally displaceable piston. Similarly with the cam type drive member. Nevertheless other arrangements are also possible - for example, with a displaceable cylinder.

Advantageously, where it is desired for the working, e.g. cutting portion of said at least one tool element to follow a substantially directly radially outwards path, at least at a radially outer portion of said path, then said at least one tool element is conveniently articulated and provided with a guide device. In more detail the tool element conveniently comprises a drive link having pivotally connected thereto a tool member, which tool member has a guide device formed and arranged for acting between said tool member and an opposed part of the body. The guide device is formed and arranged so that as said pivotally connected part of the tool member is

displaced outwardly, said tool member is angularly displaced in such a way by said guide device, so that a working portion of said tool member follows a substantially directly radially outward path, at least along a radially outer portion thereof. Conveniently the guide device is in the form of a channel or slot provided in one of said opposed body part and tool member, the other one thereof having a guide pin or the like engaged in said channel or slot.

Such an arrangement is desirable in, for example, pipe cutting applications where it is desired to cut off a length of pipe in an efficient manner i.e. by means of cutting away as little material as possible.

In other applications such as under reaming where the cutting tool is used to remove scale from the interior wall of a pipe, then the simpler form of down hole tool of the invention is preferred as the scale cutting is largely in an axial direction rather than radial direction.

With a down-hole tool of the invention, there is used a relatively simple and reliable form of displacement mechanism to swing out a tool element which makes use of the drive fluid already available for driving a down-hole motor, such as a positive displacement motor or turbine provided to rotate a drill bit or other tool provided in the bottom hole assembly. Thus the present invention provides a simple and economic form of construction, with good reliability in operation.

It will be appreciated that a wide variety of tool elements may be used in the tool of the present invention. In general these include various kinds of mechanical cutting tool elements, for example blades, suitable for cutting through metal pipes or tubing, for example, in order to cut off a

length of pipe, and/or for cutting through scale or other constricting material present inside a pipe or tube. Other kinds of tool elements which may be used in a tool of the present invention include jetting tool elements, in which a high pressure jet of fluid is used to cut through scale or other deposits, or possibly even through metal tubing or piping.

It will of course be understood that a tool of the present invention may also comprise a longitudinally extending serial array of two or more tool units which may be formed and arranged to function independently to a greater or lesser degree, or could be more or less closely inter-linked with each other.

The downhole drive fluid supply may be used to operate the piston and cylinder device in any convenient manner. In general though the tool is formed and arranged so that a drive fluid pressure drop across a flow restriction, which pressure drop varies with the drive fluid flow rate, is utilised to provide a driving force to actuate the piston and cylinder device. Typically one side of the piston and cylinder device is connected to the low pressure side of the drive fluid flow restriction and the other side is connected to the high pressure side of the flow restriction so that as the pressure differential therebetween is increased, the piston and cylinder exerts an increased force on the drive member tending to displace the tool element(s) from its (their) stowed position to its (their) deployed position. It will be appreciated that the operating characteristics of the tool of the invention may be varied considerably. On the one hand the mechanical advantage of the drive member to engagement portion drive transmission system may be varied by suitable choice of the geometry thereof. Thus, for example, the gradient of a

cam type drive member may be suitably selected. On the other hand the mechanical advantage of the piston and cylinder device may be varied by suitable choice of its geometry and/or the drive fluid pressure differential available to drive the piston and cylinder device etc, may be varied. Thus, for example, for a given pressure differential an increased displacement force can be obtained with an increased piston diameter. Also a greater pressure differential can be obtained by decreasing the diameter of the flow restriction and/or increasing the flow rate.

Further preferred features and advantages of the invention will appear from the following detailed description given by way of example of some preferred embodiments illustrated with reference to the accompanying drawings in which:

Fig. 1 is a general view of a bottom-hole assembly provided with a downhole tool of the present invention;

Fig. 2 is a longitudinal section through a pipe cutting tool of the present invention with the tool elements retracted;

Fig. 3 is a corresponding view showing the tool elements fully deployed in use for cutting off a length of pipe;

Figs. 4 & 5 are views corresponding to Figs. 2 and 3, of an under reamer;

Fig. 6 is a view corresponding to Fig. 5 showing two under reamer tools connected in series;

Figs. 7 & 8 are views corresponding to Figs. 2 and 3, of a jetting tool;

Fig. 9 is a transverse section in the plane IX - IX in Fig. 7;

Figs. 10 and 11 are detail views of a modified form of drive transmission suitable for use with the above tools; and

Figs. 12 and 13 are detail views of the fluid supply passage of the jetting tool of Figs 7 & 8.

Fig. 1 shows a bottom hole assembly (BHA) 1 supported on a coil tubing drill string 2. The BHA 1 comprise a downhole motor 3 comprising a power section 4, such as a turbine or positive displacement motor, provided with a gearbox 5, and connected via a thrust bearing unit 6 to a tool 7 of the invention at the distal end of which is mounted a drill bit 8.

As shown in Fig. 2, the tool 7 is a pipe cutting tool which comprises a central body 9 screwthreadedly connected 10 at its upper end 11 to an upper housing 12 which has a male threaded portion 13, typically with a tapered API thread, for attachment to the bit box 14 of the downhole motor 3. The lower end 15 of the central body 9 is screwthreadly connected 16 to a lower housing 17 which has a female threaded portion 18 for connection to the drill bit 8 or possibly a further tool (not shown).

The upper end 11 of the central body 9, has provided therein a cylinder chamber 19 in which is slidably mounted a piston 20 provided with sliding seals 21 and, screwthreadedly connected 22 thereto, a piston rod 23 which extends down through the lower end 15 of the central body 9. An upper portion 24 of the piston rod, spaced apart from the piston 20, has formed along opposite sides 25, 26 thereof, racks 27, 28 which drivingly inter engage respective pinion gear sectors 29, 30 provided at the pivotally mounted 31 ends 32 of tool elements 33. In order to obtain a substantially directly radially outward movement of a cutting edge 34 of the tool elements 33 - at a radially outer portion of its path from its retracted position to its fully deployed deposition, the tool element 33 is articulated and provided with a guide mechanism.

In more detail, the tool element 33 comprises a drive link 35 having pivotally connected 36 thereto, a tool member 37, which

has a guide device 38 formed and arranged so that as the pivotal connection 36 is displaced outwardly, the tool member 37 is angularly displaced in such a way by the guide device 38, so that the cutting edge 34 thereof follows a substantially directly radially outward path, at a radially outer portion thereof. The guide device 38 is in the form of a channel or slot 39 provided in the tool member 37, with a guide pin 40 provided on the central body 9, engaged therein. Such an arrangement reduces the amount of pipe material needing to be cut-away in order to cut off a length of pipe, thereby providing increased efficiency.

The teeth 41 of the racks 27, 28 and pinion gear sections 29, 30 generally have an involute profile or the like to provide efficient drive transmission and the latter are provided with projecting stops 42 for engagement with stop pads 43 secured to the central body 9, in order to limit the outward displacement of the tool elements 33.

In general at least 2, and typically 3 or 4, tool elements 33 are provided with cutting edges 34 shaped differently and/or mutually offset slightly (longitudinally of the BHA), so that each cutting element tends to cut away a different part of the pipe P, albeit there will generally be some degree of overlap between successive cutting edge cuts. The cutting edges 34 are generally of hardened tool steel or tungsten carbide or the like and conveniently are in the form of inserts into a tool member 37 of alloy steel, although of course the whole tool member 37 could be made of the same hard cutting material.

At a lower end portion 44, the piston rod 23 has a shoulder 45 which engages the upper end 46 of a compression return spring 47, the lower end 48 of which abuts a spacer 49 secured

between the lower end 15 of the central body 9, and the lower housing 17 connected thereto.

The piston rod 23 also has a central axial fluid passage 50 extending therethrough which connects to a similar passage 51 through the piston 20 and another one 52 through the lower housing 17, for passing drive fluid from the power section 3 down to the drill bit 8. The passages 50, 51 through the piston rod 23 and piston 20 are of relatively small diameter, typically around 6.35 mm (¼″), so as to provide a significant pressure drop between the cylinder 19 above the piston 20 and below the piston. If desired the pressure drop (for a given flow rate) can be further increased by providing a nozzle or like constriction 53 in the passage 50/51.

As generally discussed hereinbefore, the various parameters of the operating mechanism may be readily varied to achieve a wide range of cutting edge displacement forces etc. Typically though, in the case of an apparatus as illustrated in Figs. 2-3, in which the tool element is displacable between a minimum tool diameter of 73.03 mm (2 7/8″) and a maximum tool diameter of 150 mm (6″), using a piston having a diameter of around 44.3 mm (1 ¾″), and a fluid passage with a diameter of around 6.35 mm (¼″) and length of about 870 mm (34.25″), then there can be obtained a pressure differential of 4.9 Mpa (728 psi) at a flow rate of about 189 lpm (50gpm) with a return spring force of ca 43.8 kN/m (250 lb/in) this can provide an axial deployment force of around 6.9 kN (1560 lb) which provides a radially outward displacement force of about 385 N (87 lb).

If desired, a stabiliser 54 or centraliser may be provided immediately above or below the cutting tool 7, in order to keep the tool central in the pipe and ensure even cutting therethrough.

In use of the pipe cutting tool 7, during running of the BHA 1 into the pipe 8, the drilling fluid is passed through the motor 4 and the tool 7 at a low rate, below a predetermined maximum. This allows the motor 4 to rotate and the fluid flow may also be used to assist fluid circulation in the well as the tool 7 is run in. When the tool 7 is to be deployed the flow rate through the motor 4 and the tool 7 should be increased. As the flow is increased the pressure at the upstream side of the piston 20 will increase as the fluid is forced through the passage 50,51 and down through the body 9 of the tool. The downstream side of the piston 20 is in communication with the annulus pressure, which will be lower than the pressure within the cylinder 19 above the piston 20, via a small annular clearance between the piston rod 23 and the central body 9 below the cylinder 19. This will result in a pressure differential across the piston which will try to force the piston down the cylinder 19. Initially this force will be less than the pre-compression in the spring 47. Once a predetermined flow is achieved however, the pressure differential across the piston 20 will provide sufficient force to overcome the spring 47 and the piston 20 will slide down the cylinder 19. As the piston 20 moves down the cylinder 19, the racks 27, 28 on the piston rod 23 will also move down the central body 9. As the racks 27, 28 move, the pinion gear sectors 29, 30 will rotate on the pivot pins 31 thereby swinging out the drive links 35 which in turn pull out the tool members 37 pivotally connected 36 thereto. The pins 40 sliding in the slots 39 of the guide mechanism 38 guide the motion of the tool members 37 so that the cutting edges 34 move radially outwards to make contact with the pipe P. As the tool 7 is rotated the cutting edges 34 cut into the pipe P. As mentioned previously the cutting edges 34 are set so that the different tool elements cut at different axial

positions along the pipe P with some overlap between successive cuts. This provides a wider cut with less chance of the blades becoming stuck in a narrow slot and ensures that all cutting edges provide a cutting action simultaneously.

Once the piston 20 has reached a certain distance, the stops 42 on the drive links 35 will contact the stop pads 43 on the body 9 and the cutting edges 34 will not deploy any further. The stop position can be set to ensure that the cutting edges 34 only cut through the desired pipe wall P and do not deploy any further and damage other structures or assemblies.

Fig. 4 shows a tool 7 for use in the BHA 1 of Fig. 1 which is an under reamer, together with a drill bit 8 connected thereto. The under reamer tool 7 is substantially similar in many respects to the pipe cutting tool of Figs. 2 and 3 and like parts corresponding to those in the latter tool have been indicated by like reference numerals. The main difference in the under reamer relates to the tool elements 61 which are in the form of elongate tool members 62 driven directly by the racks 27, 28 provided on the piston rod 23. Thus the pinion gear sectors 29, 30 are provided on the proximal ends 63 of the tool members 62. It will be appreciated that in this case the tool members 62 simply swing out on their pivotal mountings 31 so that the cutting edges 64 at their distal ends 65 follow an arcuate path between the retracted position shown in Fig. 4 and the fully deployed position shown in Fig. 5. The cutting edges 64 moreover have a different geometry from that of the cutting edges 34 in the pipe cutting tool to reflect the fact that the under reamer tool cuts generally axially whilst the pipe cutting tool cuts substantially radially.

Fig. 6 shows two under reamer tools 7A, 7B such as those shown in Figs. 4 and 5, connected in series. In order to provide a progressive reaming effect, the stops 42A on the lower tool 7A are configured so that in the fully deployed position, the cutting edges 64A thereof extend out and cut to a smaller diameter than the cutting edges 64B of the upper tool 7B. The stops 42 also act to limit the extent of the radially outward deployment of the cutting edges 64 so as to prevent damage to the pipe wall P.

As shown also in the drawings, the drill bit 8 in this case is of a type particularly suitable for reaming operations with a central drill tip 66 and a series of cutting inserts 67, 68 at progressively increasing cutting diameters. As with the pipe cutting tool, the under reamer tool may also be used in conjunction with a stabiliser 54 (see Fig. 1).

The operation of the under reamer tool is substantially similar to that of the previously described pipe cutting tool. Thus during running in of the tool, the tool elements 33 are maintained in their retracted positions as shown in Fig. 4, by the return spring 47 acting on the piston rod 23. When the fluid flow rate is increased until the differential fluid pressure acting on the piston 20 is sufficient to overcome the biasing force of the return spring 47, the tool members 37 swing out to their deployed position as shown in Fig. 5 whereupon they can cut away any scale S on the inside of the pipe P as the BHA 1 is advanced axially along the pipe P.

Fig. 7 shows a tool 7 for use in the BHA 1 of Fig. 1, which is a jetting tool. The jetting tool 7 is similar in many respects to the under reamer and pipe cutting tools and like parts corresponding to those in the latter tools have been indicated by like reference numerals. As with the under

reamer, the tool elements 71 are in the form of a simple elongate pivotally mounted tool members 72. The main difference in this case relates to the nature of the drive transmission between the piston 20 and the tool members 72.

In more detail, the piston rod 23 is provided with a cam portion 73 with three angularly spaced apart raised portions in the form of radially outwardly extending lobes 74A (see also Fig. 9) separated by low portions 74B, which interengage with cam follower portions 75 provided at the inner faces 76 of the tool members 72. In addition the piston 20 is provided with a guide device 77 in the form of a helical guide channel or slot 78 on the outer face 79 of the piston 20 and a guide pin 80 projecting inwardly from the wall 81 of the cylinder 19 for guiding engagement with the guide channel 78, so that as the piston 20 is displaced axially it is also constrained to rotate thereby bringing the outwardly projecting lobes 74 of the cam portion 73 into engagement with the cam follower portions 75 so as to swing out the tool members 72. When the fluid pressure acting on the piston 20 is reduced allowing the piston 20 to be driven back by the return spring 47, then the low cam portions 74B engage inwardly projecting corner portions 72A of the tool members 72 and forcibly rotate the tool members 72 about their pivot pins 31, thereby retracting the tool members 72 back into the tool. As with the pipe cutting tool of Figs. 2 and 3, stops 42 are provided (in this case on the tool members 72) for contacting stop pads 43 on the body 9 to limit radially outward movement of the tool members 72.

The tool members 72 moreover have jetting nozzles 82 in place of cutting edges. The jetting nozzles 82 are supplied with fluid via conduits 83 extending through the tool members 72 and connected to a fluid supply 84 in the tool body 9.

In more detail, as shown in Figs 12 and 13, the fluid supply 84 comprises a clearance gap 85 between the outer face 79 of the piston 20 and the wall 81 of the cylinder 19 in communication with the guide channel 78 which in the deployed position of the jetting tool shown in Fig. 8, is brought into registration with an outwardly extending passage 86 which is connected via a longitudinally extending passage 87 in the body 9 to a flow passage arrangement 88 at the tool member mounting pivot pin 31 (see Fig. 9). In the retracted position of the jetting tool shown in Fig. 7, an annular seal 89 on the piston 20 is brought into position above the outwardly extending passage 86 thereby closing off the fluid supply via the clearance gap 85 and guide channel 78, to the outwardly extending passage 86. The passage arrangement 88 comprises a central passage 90 extending axially along the pivot pin 31 from an end 91 where the longitudinal passage 87 exits, to a radially extending passage 92 in the pin 31 which exits into a part-annular groove 93 provided in a bore 94 in the tool member 72, in which bore 94 the pivot pin 31 is received. The groove 93 in turn communications with the conduits 83 which extend through the tool member 72 and is formed and arranged so that the radial passage 92 in pin 31 moves out of registration with the part-annular groove 93 in the tool member 72 when the tool member is retracted, thereby shutting off the fluid supply to the jetting nozzles 82.

As also shown in Fig. 9, the pivot pins 31 are provided with seals 94, 95 for sealing between the pivot pin 31 and the body 9 and tool member 72, respectively. The pivot pins 31 are held captive in blind bores 96 extending through the body 9 by retaining bolts 97, screwed into part 98 of the body 9 adjacent the bores 96.

The operation of the jetting tool is generally similar to that of the previously described pipe cutting tool end under reamer tool. Thus during running in of the tool, the tool elements 33 are retained in their retracted positions as shown in Fig. 7 and further explained hereinbelow. When the fluid flow rate is increased sufficiently until the differential fluid pressure acting on the piston 20 is sufficient to overcome the biasing force of the return spring 47, the piston 20 is displaced axially. The guide device 77 now forces the piston 20 to rotate thereby imparting a helical movement to the cam lobes 74 which in turn, through their interaction with the cam follower portions 75, force the tool members 72 to swing out to their deployed position as shown in Fig. 8. At the same time the fluid supply 84 is connected to tool member conduits 83 and jetting nozzles 82 so that jets 98 of fluid are directed out of these against the sides of the pipe P, for example, in order to remove deposits of scale S therefrom.

Figs. 10 and 11 show a modified embodiment of drive transmission in use with an under reamer (but which could equally well be used with a pipe cutting tool or jetting tool as described hereinbefore). In more detail the rack and pinion drive transmission systems 27-30 of the under reamer of Figs. 4 and 5 are replaced by a worm gear drive 99 with a helical screw worm gear 100 engaging pinion gear portions 29,30 on the tool members 62. The worm gear 100 is rotated by means of a guide device 77 provided on the piston 20 in the form of a helical guide channel or slot 78 and guide pin 80 inter engaged therewith which constrains the piston 20 to rotate as it is displaced axially, in substantially similar manner to that described hereinbefore with reference to the jetting tool of Figs. 7 and 8.

It will be appreciated that various modifications may be included in the above-described embodiments. Thus, for example, it is generally desirable to provide drive fluid supply ports 110 in the vicinity of any drive mechanisms such as the rack and pinion or worm gear and pinion gear wheel mechanisms in Figs. 2-5 and 10-11, in order to divert some drilling fluid flow from the central axial fluid supply passage 50 to help keep clean these mechanisms. Advantageously there may be provided ports 111 in the upper housing 12 for connecting the cylinder chamber 19 above the piston 20 to the exterior of the tool 7 to control the pressure applied to the piston 20 and thereby the force generated thereby and applied to the tool elements / members 33, 61, 71. By inserting closure blanks or suitably dimensioned nozzles in the ports 111 prior to lowering the tool downhole according to the expected working conditions, then various degrees of fluid venting and hence limitation of the pressure differential across the piston 20 can be readily obtained, or venting prevented. Furthermore, in the case of the jetting tool there could be employed a simplified form of fluid supply to the jetting nozzles 82. In more detail, the longitudinally extending passage 87 in the body 9, flow passage arrangement 88 at the tool member mounting pivot pin 31, and upstream ends of the tool member conduits 83, could be replaced by flexible hoses routed along channels running from the outwardly extending passages 86 along the outside of the body 9 and channels along the inside of the tool members 72 up to the jetting nozzles 82.

CLAIMS

1. A down-hole tool with at least one radially outwardly deployable tool element for use in a bottom hole assembly provided with a pressurised down-hole motor drive fluid supply, which tool comprises a body having at least one tool element having a mounting, proximal, end portion pivotally mounted on said body, and a working, distal, end portion displaceable between a stowed, radially inward, position and a deployed, radially outward, position, said proximal end portion being provided with an engagement portion formed and arranged for driven engagement with a drive member axially displaceable by a piston and cylinder device operable, in use of the tool, by means of said pressurised drive fluid supply, so as to rotate said proximal end portion and displace said tool element working end portion between said stowed and deployed positions thereof.

2. A tool as claimed in claim 1 wherein the drive member is provided with a guide device mounted for action between the drive member and an opposed body part so as to impart an angular rotational displacement to the drive member when it is axially displaced by said piston and cylinder device.

3. A tool as claimed in claim 2 wherein said guide device comprises a guide channel or slot and a guide pin received in said channel or slot for running therealong.

4. A tool as claimed in claim 3 wherein said guide channel or slot extends helically around a generally cylindrical part of the drive member.

5. A tool as claimed in claim 3 wherein said guide channel or slot has a 'J' shaped form.

6. A tool as claimed in any one of claims 2 to 5 wherein the engagement portion comprises a pinion gear sector portion, and the drive member is provided with a worm gear portion.

7. A tool as claimed in claim 1 wherein the engagement portion comprises a pinion gear sector portion, and the drive member is provided with a rack gear portion in the case of a drive member having only an axial component of motion.

8. A tool as claimed in claim 1 wherein the drive member is provided with a cam portion and the engagement portion constitutes a cam follower.

9. A tool as claimed in any one of claims 1 to 8 wherein the piston and cylinder device is provided with a resilient biasing means formed and arranged for urging said drive member towards a stowage position in which said at least one tool element is stowed, said piston and cylinder device being formed and arranged for displacement of said drive member against the biasing force of said resilient biasing means when an increased fluid pressure differential is applied to said piston and cylinder device.

10. A tool as claimed in any one of claims 1 to 9 wherein said at least one tool element is articulated and provided with a guide device formed and arranged so that said working end portion of said at least one tool element is constrained to follow a substantially directly radially outwards path, at least at a radially outer portion of said path.

11. A tool as claimed in claim 10 wherein the tool element comprises a drive link having pivotally connected thereto a tool member, which tool member has a guide device formed and arranged for acting between said tool member and an opposed

part of the body, said guide device being formed and arranged so that as said pivotally connected part of the tool member is displaced outwardly, said tool member is angularly displaced by said guide device, so that a working portion of said tool member follows a substantially directly radially outward path, at least along a radially outer portion thereof.

12. A tool as claimed in claim 11 wherein the guide device is in the form of a channel or slot provided in one of said opposed body part and tool member, the other one thereof having a guide pin engaged in said channel or slot.

13. A tool as claimed in any one of claims 1 to 12 wherein is provided a plurality of, angularly distributed, radially outwardly deployable tool elements.

14. A tool as claimed in claim 13 wherein is provided from 2 to 4 of said tool elements.

15. A tool as claimed in any one of the proceedings claims wherein said tool element is selected from a mechanical cutting tool and a jetting tool.

16. A tool as claimed in claim 15, wherein is provided a said tool element suitable for use for pipe cutting applications where it is desired to cut off a length of pipe.

17. A tool as claimed in claim 15, wherein is provided a said tool element suitable for use for under reaming where the cutting tool element is used to remove scale from the interior wall of a pipe.

18. A tool as claimed in any one of claims 1 to 17 wherein the piston and cylinder device is provided with a pressurised

fluid supply connection formed and arranged so that a drive fluid pressure drop across a flow restriction, which pressure drop varies with the drive fluid flow rate, is utilised to provide a driving force to actuate the piston and cylinder device.

19. A tool as claimed in claim 18 wherein one side of the piston and cylinder device is connected to the low pressure side of the drive fluid flow restriction and the other side is connected to the high pressure side of the flow restriction so that as the pressure differential therebetween is increased, the piston and cylinder exerts an increased force on the drive member tending to displace the tool element(s) from its (their) stowed position to its (their) deployed position.

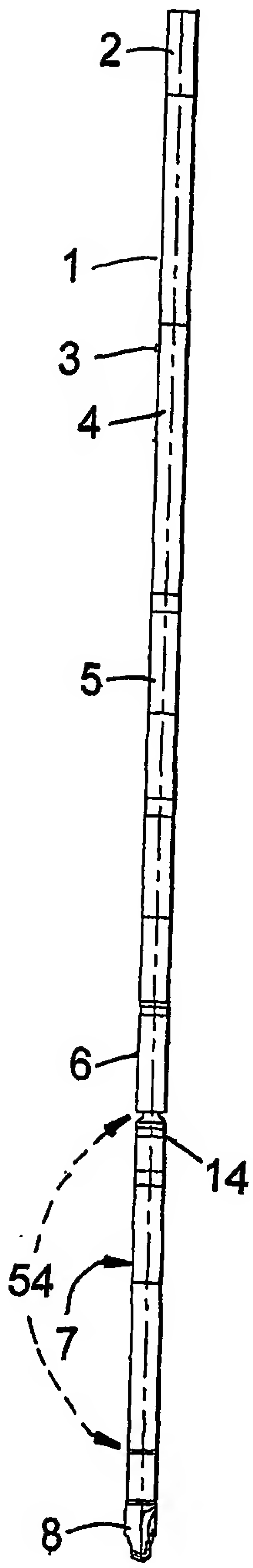

Fig. 1

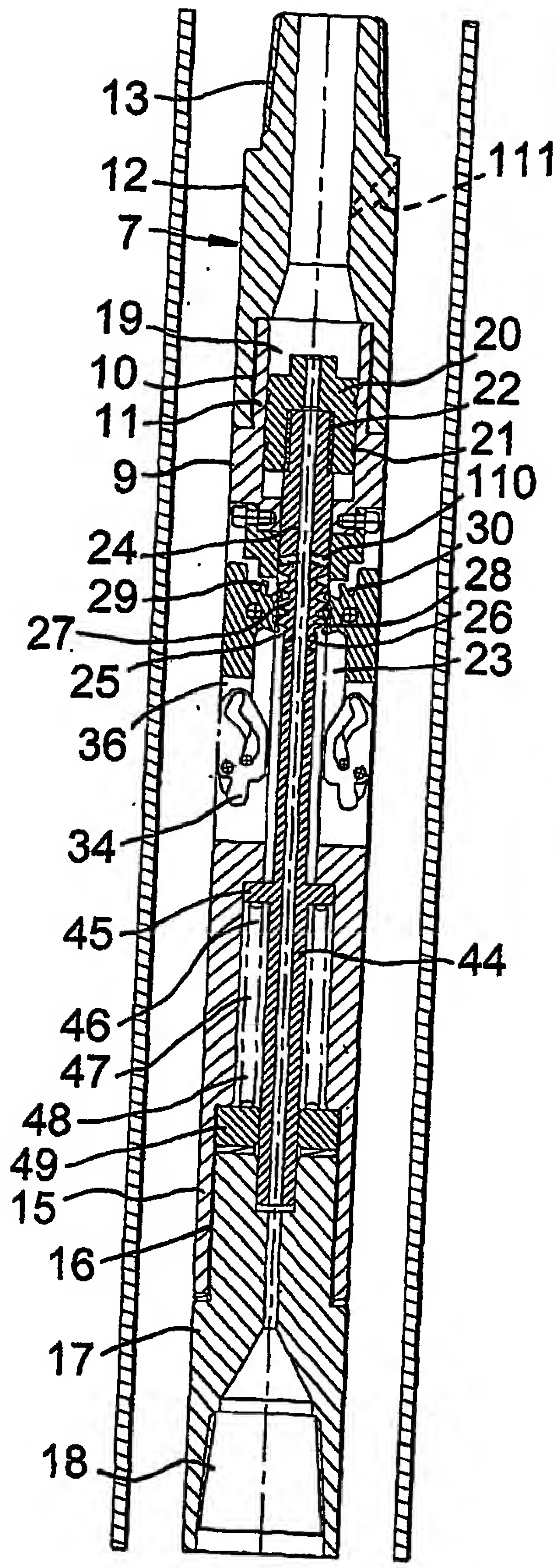

Fig. 2

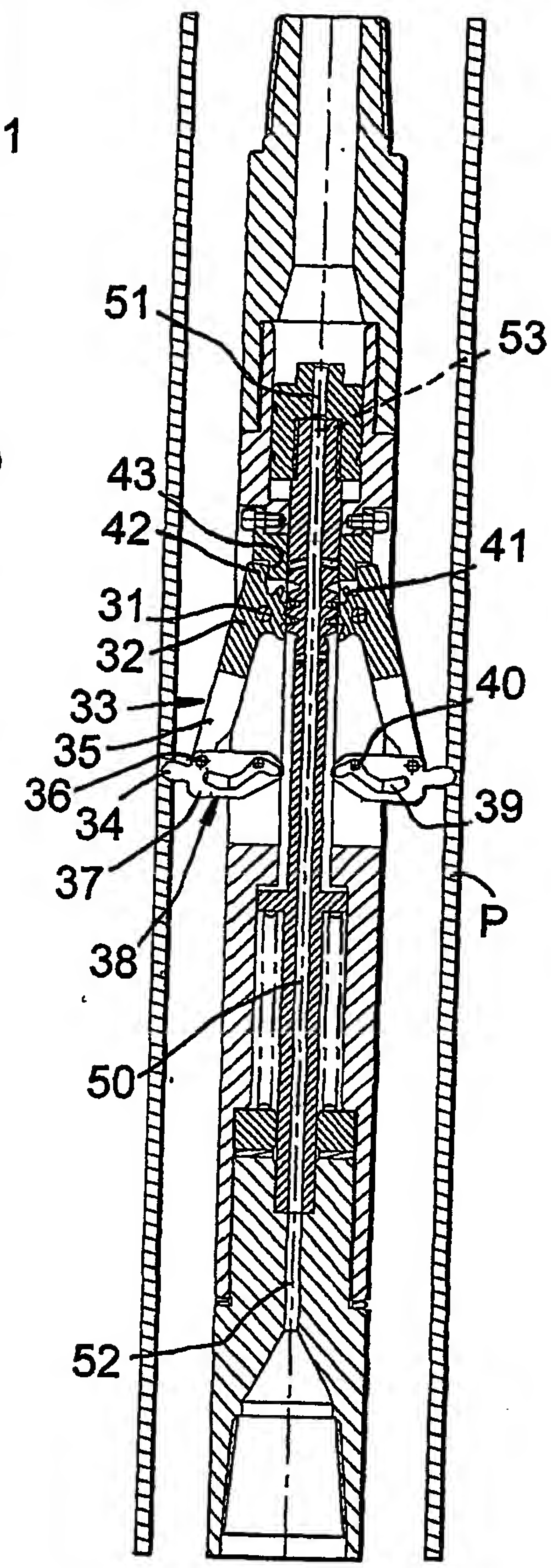

Fig. 3

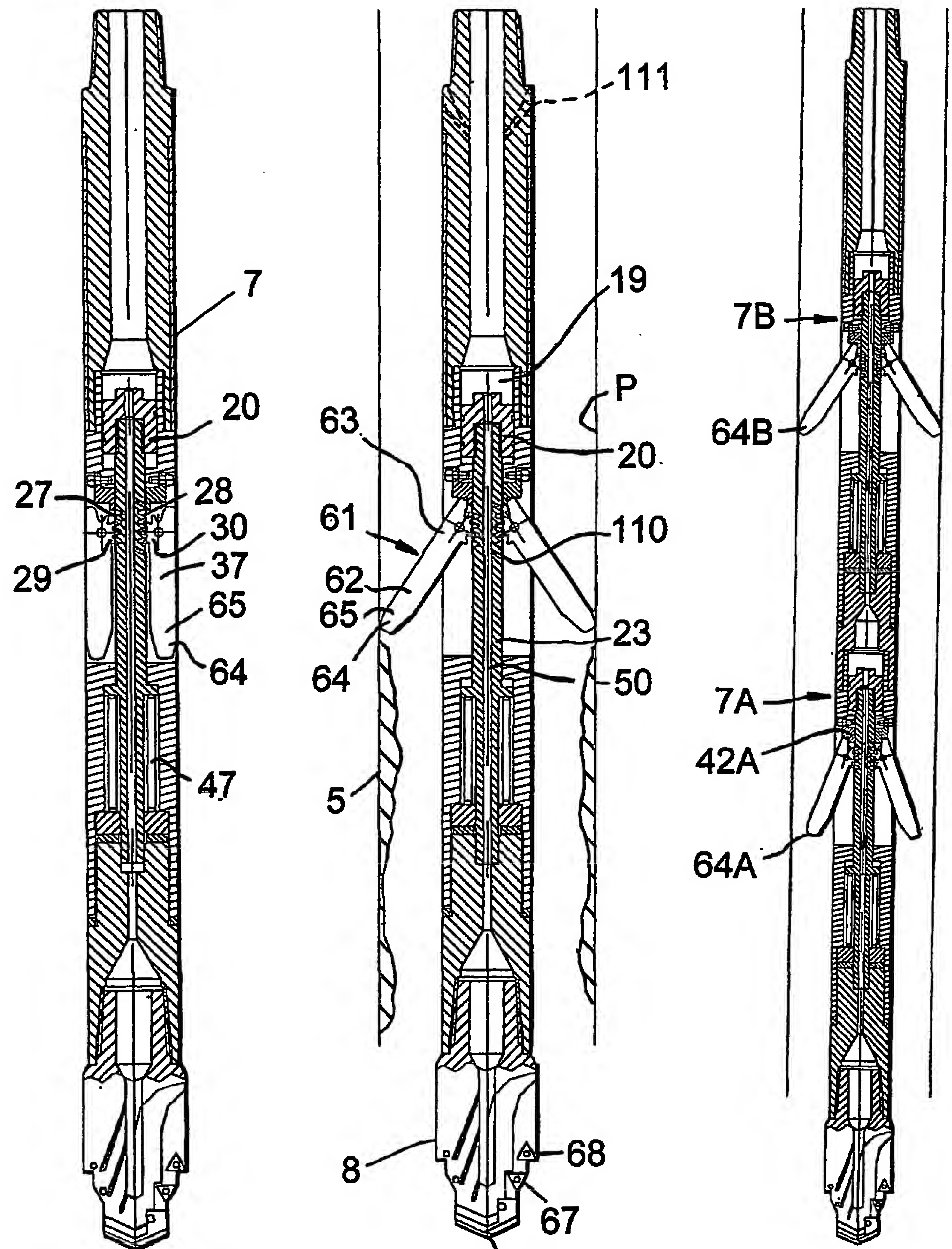

Fig. 4

Fig. 5

Fig. 6

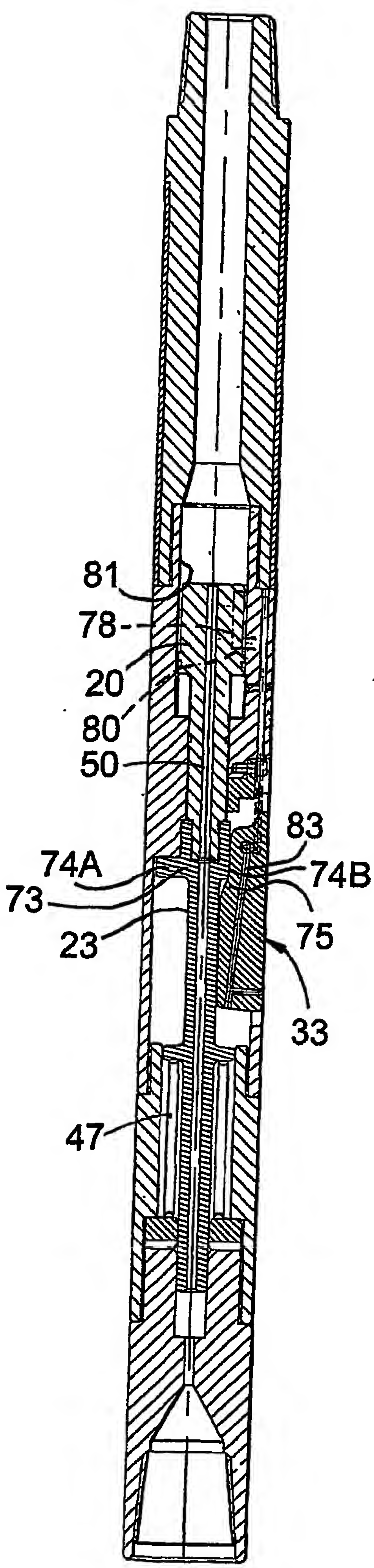
81
78
20
80
50
83
74A
74B
73
75
23
33
47

Fig. 7

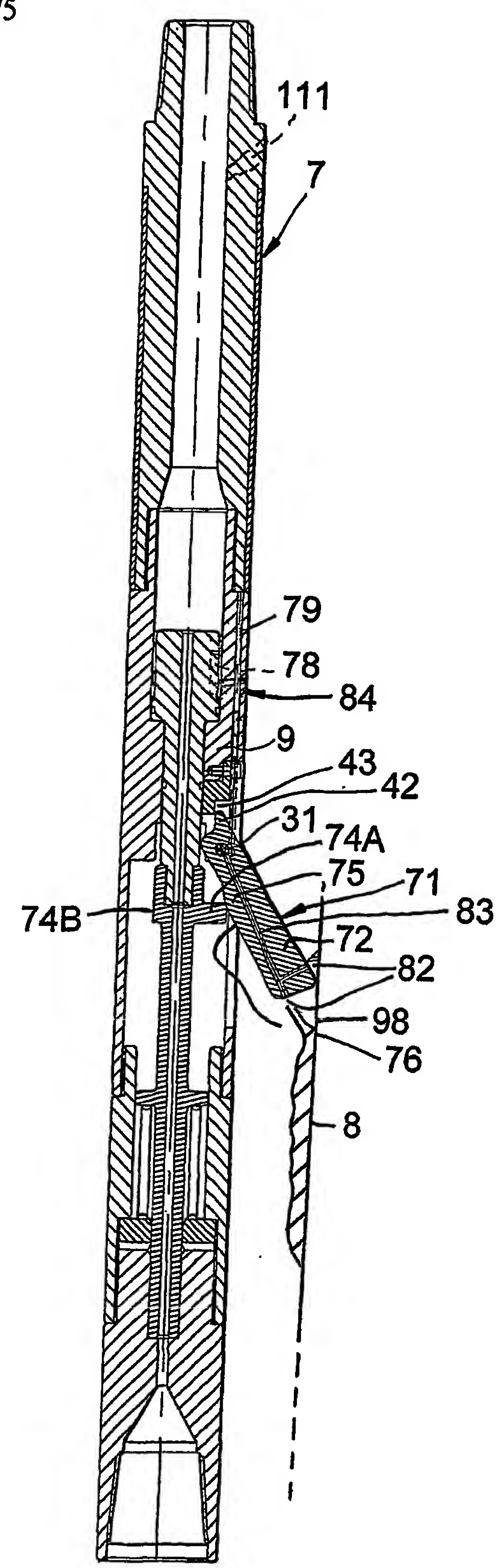
111
7
79
78
84
9
43
42
31
74A
75
71
74B
83
72
82
98
76
8

Fig. 8

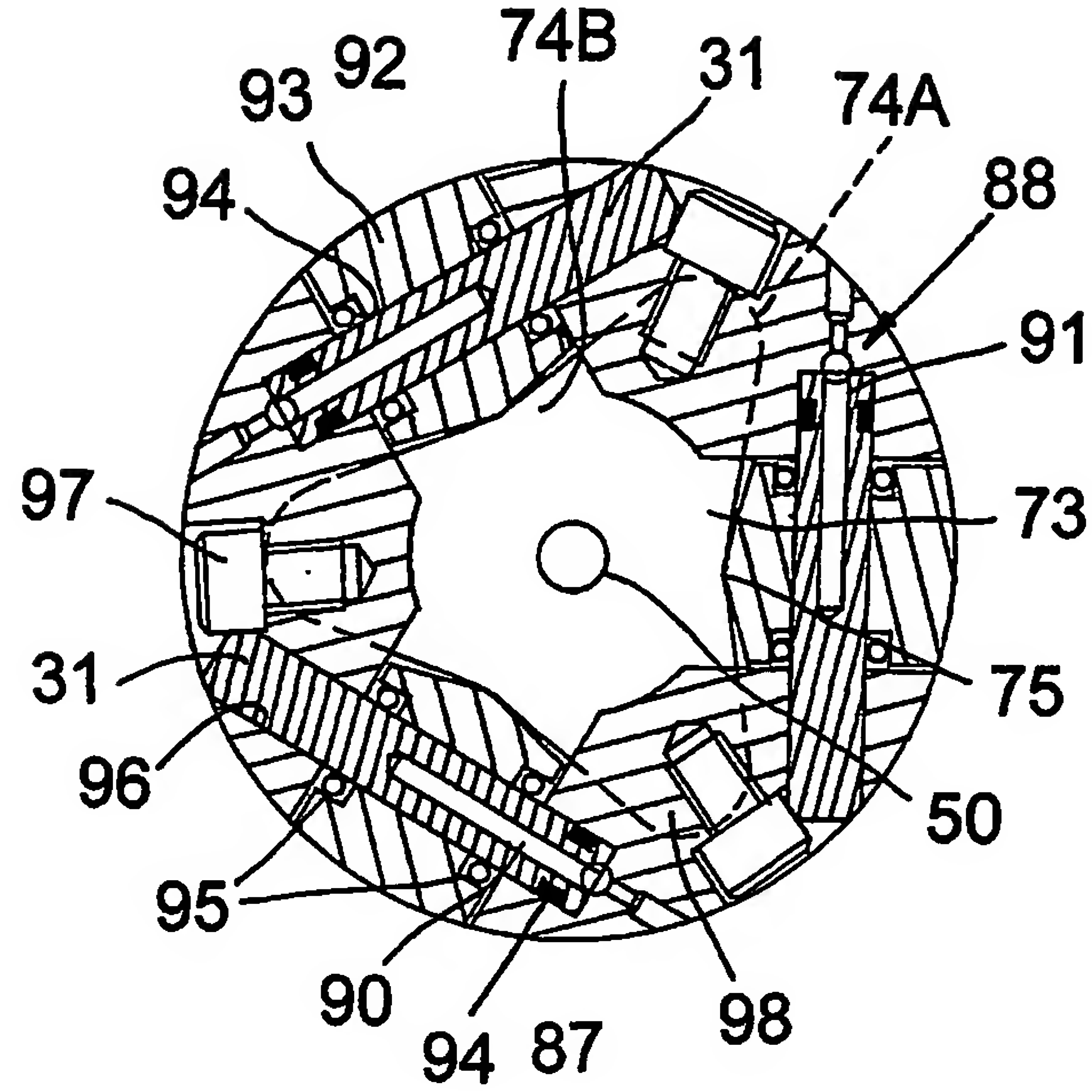

Fig. 9

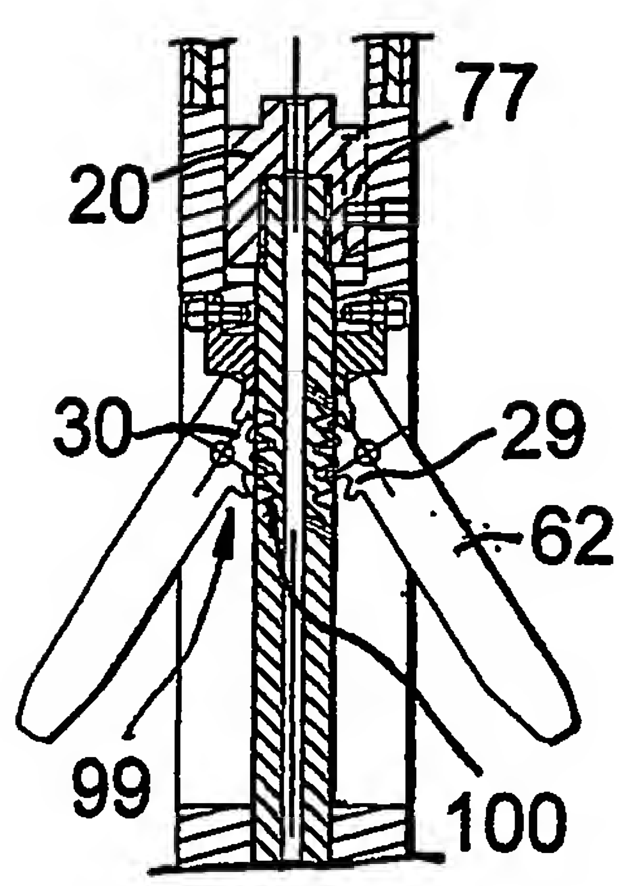

Fig. 10

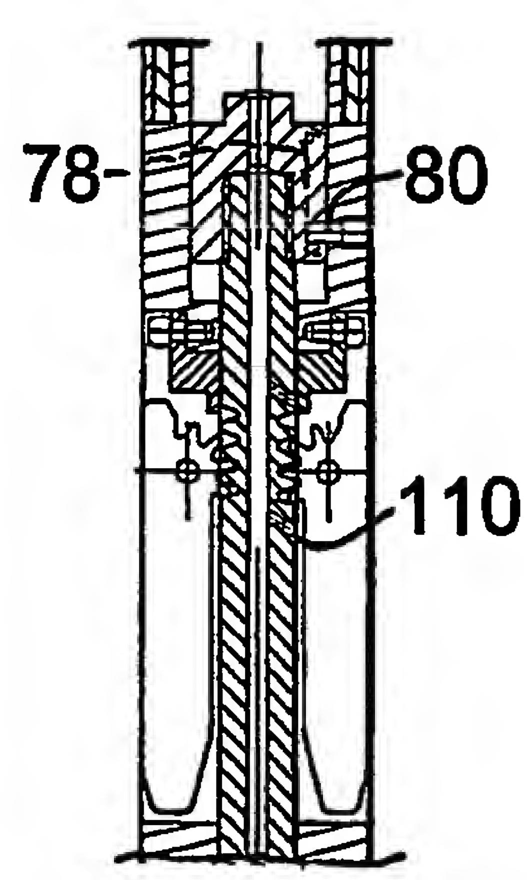

Fig. 11

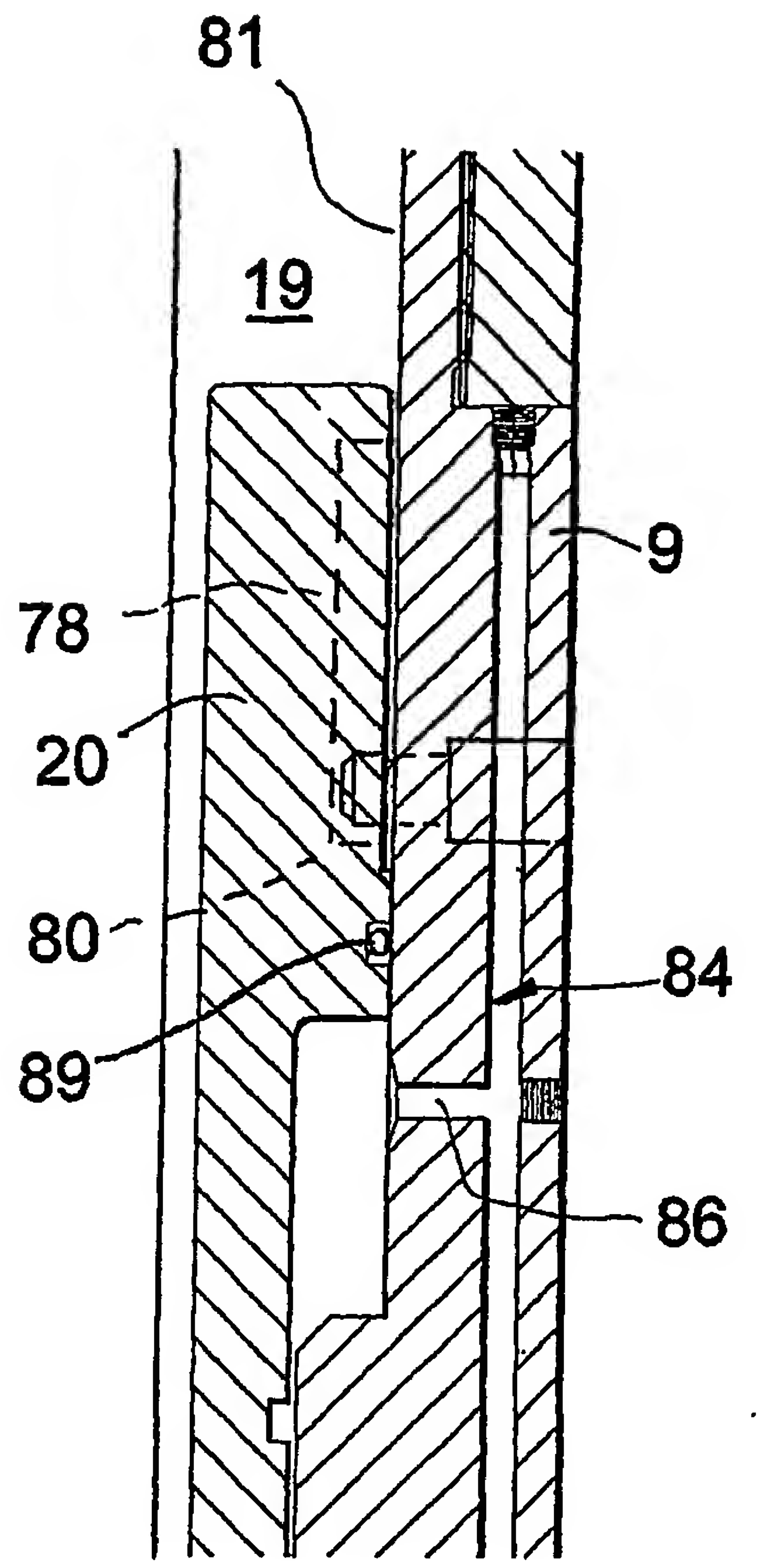

Fig. 12

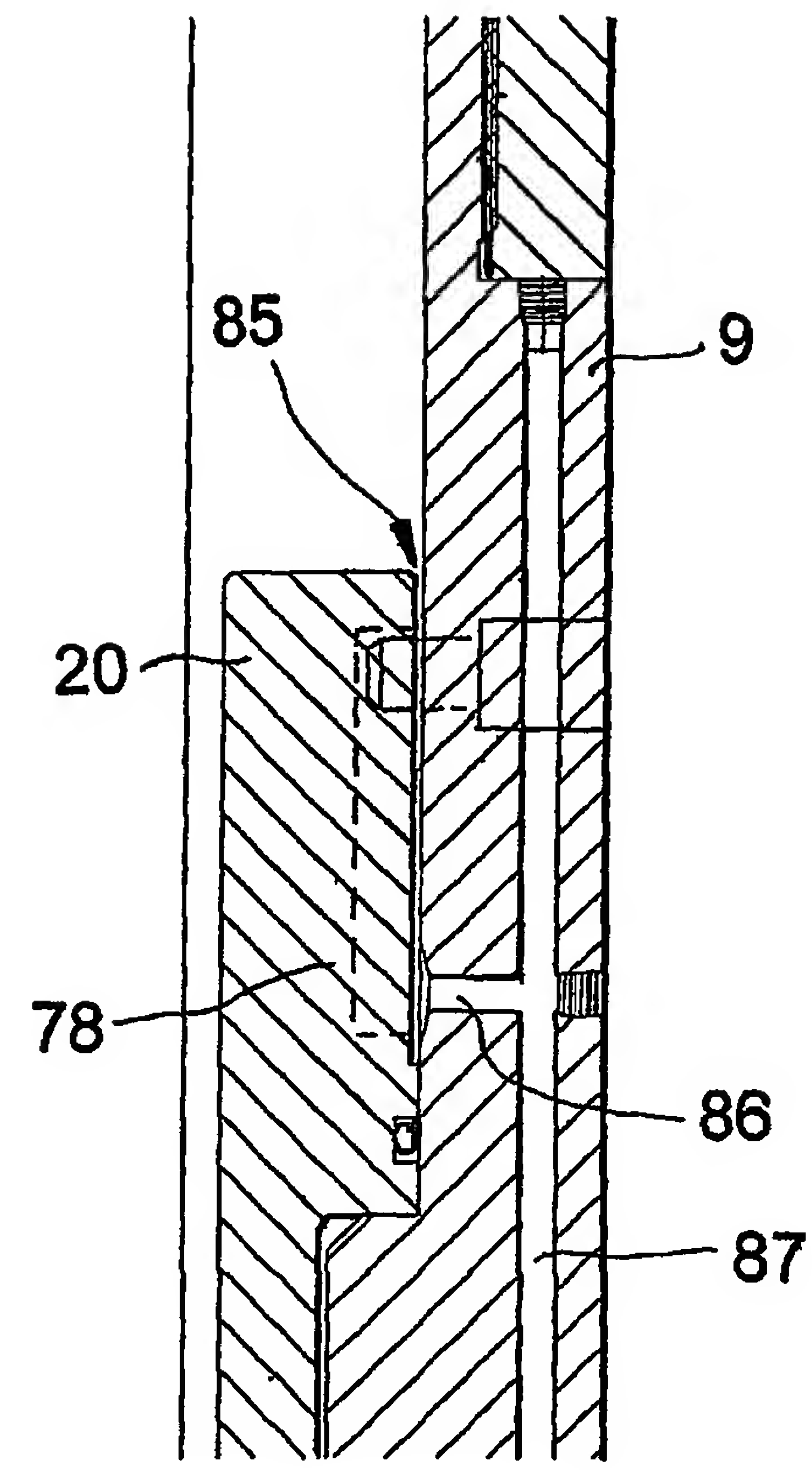

Fig. 13